AMICON SYSTEM SPECIFICATION

Draft Revision 1.02
May, 1980

This is a draft version of specifications for use of the data communications special service channel (L2) on the AMSAT Phase III satellite, the communications medium which serves as the foundation of the AMSAT International Computer Network (AMICON). This document is subject to final approval by the Board of Directors of AMSAT. As a draft document it is subject to discussion, negotiation, further study, and potential rewrite of major sections. This document has not been approved for general publication. The contents herein represent the current thinking of the authors, and your comments and criticisms will be most welcome.

Comments and questions should be directed to:

AMICON System Architecture Design Group

c/o

H. S. Magnuski, KA6M, 311 Stanford Ave., Menlo Park, CA 94025
(415) 854-1927

FOREWORD

The Radio Amateur Satellite Corporation (AMSAT, P.O. BOX 27, WASHINGTON, D.C. 20044) will launch, courtesy of the European Space Agency, their Phase III satellite sometime during May, 1980. Unlike previous satellites OSCAR's 7, 8, etc., the Phase III machine will be in an orbit permitting extended communications periods for stations in the coverage area. Effective use of its 70 cm to 2 meter transponder will require more detailed planning and coordination than with previous OSCAR's, and a bandplan for the 180 kHz passband has already been approved by the AMSAT Board of Directors. Part of the plan makes provisions for six special service channels (General Voice Bulletins, Education Services, Scientific Services, Traffic, CW/RTTY bulletins and code practice, and Data Communications). The procedures for use of the Data Communications Special Service Channel, also known as Special Service Channel 'Lower 2' (SSC L2), is the concern of this document.

The explosive growth of the use of computers by radio amateurs, coupled with the potential of this new communications medium lead to fantastic possibilities for the establishment of two-way computer links, computer networks, packet radio gateways for long haul traffic, and even digitized voice or video. The realization of this potential, however, requires that communications standards be established so that common equipment and protocols can be used and shared by all interested operators. The standards must also consider and be compatible with other users of the spacecraft transponder. Thus, the contents of this document not only prescribe frequency assignments and modulation techniques, but also outline rules for time-shared use of the channel, packet layout, network protocols and other related matters.

The authors realize that standards are a two-edged sword, and have tried to obtain a balance between weak standards, which allow development in too many different directions, and overly restrictive standards, which could stifle creativity.

Contributors to this document include:

Vern Riportella	WA2LQQ	AMICON Coordinator
H. S. Magnuski	KA6M	N. Cal. AMICON Coordinator
Mark Kaufmann	WB6ECE	Network Design Consultant
Gary Hendra	WA6SUW	Digital Systems Engineer
Gary Fariss	W6KYF	Software Systems Engineer

and many other radio amateurs who have offered constructive criticisms of the plans detailed herein.

PREFACE

Amicon System Specification for the AMSAT Phase III Satellite Channel L2

The AMSAT Board of Directors considering

a) that there is an urgent need for a common modulation method and accepted set of channel usage procedures (Level 1 Interface);

b) that there should be a specified format for transmitting message blocks over the channel (Level 2 Interface);

c) that there is a compelling need for coordination among the stations wishing to transmit and receive messages and files on the system (Level 3 Interface);

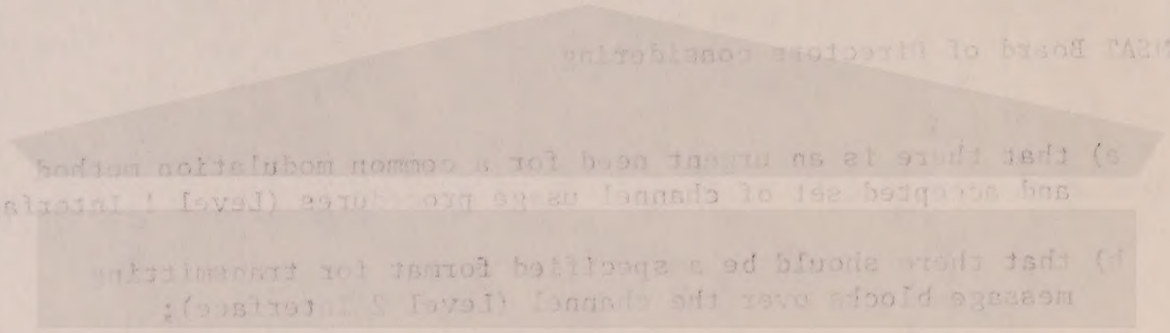
d) that future use of the channel would be greatly enhanced by commonly agreed to specifications for the most heavily used types of data communications (Level 4 Interface);

unanimously declares the view

that the following system specifications be adhered to by all stations using the special service channel for data communications on the AMSAT Phase III Satellite.

[Note: Text within square brackets in the following document is background discussion material designed to inform the reader of some of the issues involved in the design of the specification. It is not part of the formal document and is subject to deletion once the final draft is approved.

The current practice for specifying network architectures is to define independent functions in separate groups or layers. This document follows that design principle by proposing that AMICON be split into four distinct levels. The first level deals with the transmission channel and defines how a bit stream is transmitted between two stations. The second level superimposes characters and blocks of characters on the bit stream. The third level describes how blocks of characters are routed and sequenced through the network. The fourth level deals with the transmission of information which may span multiple blocks and which requires end-to-end checking.]



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Chapter 1

LEVEL 1 INTERFACE: PHYSICAL INTERFACE

1.1 Channel Assignment and Characteristics

The AMSAT Phase III satellite has one inverting transponder with a 70 cm uplink and a 2 meter downlink. The bandplan assignment is based on the 2 meter downlink, which serves as the frame of reference. Subject to final calibration after launch, the passband center is 435.215 MHz for the uplink, and 145.900 for the downlink. There are two beacons marking the edges of the downlink passband, the lower "General" beacon at 145.810 MHz, and the upper "Engineering" beacon at 145.990 Mhz. The special service channels L1, L2 and L3 are allocated spectrum at 17, 21 and 25 kHz center frequencies above the General beacon. Channels H1, H2 and H3 are located at 17, 21 and 25 kHz center frequencies below the Engineering beacon. The L2 channel has been allocated for data communications and computer networking (nominally 435.284 MHz uplink, 145.831 MHz downlink).

The originating station must control the 70 cm uplink frequency such that the 2 meter downlink frequency (as monitored at the originating station) is at the specified offset from the pilot beacon to within a tolerance of +/- 1.0 kHz. Use of the SSCs with equipment incapable of this tolerance is discouraged.

[The 3 dB bandwidth being specified for the other channels is 2.4 kHz, and the data communications spectrum will probably have to meet this spec. The 1.0 kHz frequency tolerance was taken from the June 1979 AMSAT Newsletter, and may prove to be too loose for the L2 channel.]

1.2 Channel Access and Usage

In order to provide maximum channel utilization and to eliminate contention for channel time, a well organized system of coordinators and procedures is essential. Authority to use the channel comes from the AMSAT Phase III Operations committee. The special service channel coordinator member of the committee will appoint three regional coordinators to deal with channel usage in their respective regions. The regional L2 coordinator is responsible for assigning time slots for different modes of operation and L2 usage. Within a given timeslot, where the modulation and protocol implementations are compatible, access to the channel will be governed by the algorithms specified in Chapter 2.

1.3 Carrier and Modulation Specifications

[The selection of a suitable carrier and modulation scheme will be the subject of some debate within the amateur community, and currently there is no technique which can be considered the preferred method. The relative efficiencies of synchronous transmission probably will preclude any asynchronous modulation method. The following is a list of some of the considerations which are relevant to use of the L2 channel:

Power budget of the transponder
Channel 3db bandwidth or signalling speed in b/s per Hz.

Chapter 1

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1.1 Channel Assignment and Characteristics

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The orienting station must control the 70 cm uplink frequency such that the 2 meter downlink frequency (as monitored at the orienting station) is at the specified offset from the pilot beacon to within a tolerance of +/- 1.0 kHz. Use of the SSCs with equipment incapable of this tolerance is discouraged.

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Power budget of the transponder
Channel 3db bandwidth or signalling speed in b/s per Hz.

Doppler shift
Frequency offset between sequential users of the channel
Eb/No (dB) for the modulation technique
Performance in the presence of cw interference
Channel capture capability
Complexity for the implementation
Cost of implementation and availability of hardware
Regulatory and licensing considerations

Two of the more frequently mentioned techniques are SSB and AFSK-FM. Karl Meinzer, in the June 1979 AMSAT bulletin, has outlined the use of uncoded PSK for the telemetry channel of the satellite.

What we really need now is a written proposal covering the three major modulation methods and an evaluation of each method in terms of the criteria outlined above. A summary of the principle methods includes:

AM - On-Off Keying with non-coherent detection
Quadrature Amplitude Modulation
Quadrature Partial Response

FM - FSK, non-coherent detection
CP-FSK, continuous phase FSK
MSK, minimum shift keying

PM - BPSK, binary phase shift keying
DE-PSK, differential encoded phase shift keying
QPSK, quaternary phase shift keying
OK-QPSK, offset keyed quternary phase shift keying

A very excellent and current summary of modulation methods for radio work can be found in 'A Comparison of Modulation Techniques for Digital Radio' by John D. Oetting, IEEE Transactions on Communications, Vol. COM-27 No. 12, December, 1979. This article would serve as a good basis for our comparisons of different schemes.]

1.4 Transmission Timing

The following description outlines a typical transmission. The times t0, t1, ... use as a point of reference the output antenna of the transmitting station. Note that there is a corresponding set of times s0, s1, ... which may be referenced at the output antenna of the transponder, and a third set r0, r1, ... which may be referenced at the receiver.

t0 - The transmitter places carrier on the channel. The transmitter assumes that the channel is idle and unused prior to t0.

t1 - Modulation is placed on the carrier such that all receivers assume a logical one or marking condition. Note that t1 may be the same as t0.

t2 - Denotes the start of the first idle flag or synchronization character.

t3 - Defines the transition between the last idling or synchronization character and the first byte of the packet.

t4 - The time at the end of the last checksum or crc byte.

t5 - The time at the end of the last idle flag, sync character or pad character. The channel goes into a marking condition.

t6 - The instant that modulation is removed from the carrier. Note that t5 and t6 may coincide.

t7 - The removal of all carrier by the transmitter. This time may coincide with t6.

All stations must comply with the station identification requirements imposed by their licensing authority. However, since this channel may be heavily utilized, the time taken for id should be kept to the minimum allowed. All cw identification should occur between t0 and t3.

Chapter 2

LEVEL 2 INTERFACE: PACKET TRANSMISSION SPECIFICATIONS

2.1 Packet Framing Specifications

The format of the message block or packet transmitted on the channel shall be in compliance with ISO Standard 3309 'High-level Data Link Control Procedures - Frame Structure.' Use of extended address and control fields, as detailed in the standard, is not recommended. The information field length within each packet shall be a multiple of 8 bits.

[The use of HDLC format could be controversial. The standards, techniques and equipment for the use of true, bit-oriented HDLC are still fairly new to the industrial world. The requirements for constructing an HDLC frame seem impossibly complex at first, and they would be except for the fact that many semiconductor companies have designed and are currently selling (for prices in the $30-$50 range) chips which do all the hard work. Here is a list of currently available HDLC oriented chips:

Fairchild 3846/6856	Synchronous Protocol Comm. Controller
Intel 8273	SDLC/HDLC Protocol Controller
Motorola 6854	Advanced Data Link Controller
Motorola 68561	Multi-protocol Controller
Nippon Electric Co. UPD379	SDLC Protocol Controller
Signetics 2652	Multi-protocol Controller
Standard Microsystems 5025	Multi-protocol Controller
Western Digital 1933	Synchronous Data Link Controller
Zilog SIO	Serial I/O Controller

The HDLC protocol is being designed into new equipment by all major manufacturers, and it forms the basis for the new international packet switching networks. It will be the standard for data communications in the eighties. If we are in the process of creating a digital networking specification for use over the next ten years, we should build on what is currently accepted industrial practice, even though most amateurs may be unfamiliar with the details involved. A group of pioneering Canadian operators has already conducted experiments using HDLC chips and established an HDLC beacon on 20 meters, so we have evidence that the technology is not out of reach of the amateur community. The main drawback with specifying bit-oriented HDLC is that it is incompatible with commonly used USARTs, such as the 8251A.

Also, note that this spec only calls for frames from the HDLC standard. The complete HDLC protocol is probably not appropriate for our multiple-access broadcast oriented packet repeater.

A question has been raised as to the legality of use of HDLC frames in the U.S. and other countries. In opening up radio communications to ASCII, the FCC only specified Baud rates, and did not rule on formats for start/stop bits, synchronous protocols, etc. The U.S. version of HDLC is an ANSI Standard, X3.66-1979, Advanced Data Communication Control Procedure. We need a legal opinion on use of this standard by U.S. amateurs. If HDLC framing is also outlawed in many other countries, or if waivers cannot be easily obtained, then

it would be unwise to spec it for the satellite.]

2.2 Transmission Code

The transmission code used for text characters within the message shall meet the standards set by C.C.I.T.T. Recommendation V.3 - International Alphabet No. 5.

[This is the international standard corresponding to ANSI Standard X3.4-1968 'Code for Information Interchange - ASCII.']

2.3 Channel Multiple Access Protocol

When channel usage is low, packets may be transmitted using a simple ALOHA protocol. When utilization becomes heavy, packets will be exchanged on the channel using an S-ALOHA protocol with closed loop control.

2.3.1 Definitions

A multiple-access-channel is a communications channel where many transmitting stations can attempt to access a receiving station using a common transmission medium and equipment. The uplink to the Phase-III satellite is a multiple-access channel.

A broadcast-channel is a communications channel where many stations can receive messages from a single transmitting station. The downlink of the Phase-III satellite is a broadcast channel.

The term carrier-sensed multiple-access channel (CSMA) describes a situation where each transmitter is able to detect the carrier (presence of an on-going transmission) from all other transmitters. The Phase III input channel has this characteristic except for the fraction of a second delay at the beginning of a transmission when the input signal has to travel to the satellite and return to receiving groundstations. The use of carrier sensing improves channel efficiency, particularly for longer packets.

Due to the fact that transmissions are occuring at random with no centralized control, there is the possibility of overlap of transmitted packets or collisions, where two or more transmitters are on the air at the same time. For efficient use of the channel it is important that each station be able to monitor its translated signal and check the validity of the returned packet while it is being transmitted. This ability to receive one's own packets and validate their contents is called a collision detection capability.

At any given time, using the output antenna of the transponder as our point of reference, the channel will be either be inactive with no carrier present or active with carrier. The channel duty cycle is the percentage of time that the channel is active. This measurement should be made over an extended period of time, at least 15 minutes or more.

A set of rules and procedures for controlling the exchange of messages on a communications channel is a communications protocol. Of the many hundreds of communications protocols currently in use there is a set of protocols, known as ALOHA protocols, which are concerned with regulating the flow of messages or packets on communications media where the messages are sent using a multiple-

access channel and received on a broadcast channel. The name 'ALOHA' is used because much of the initial research and the first implementations were done by the University of Hawaii in the construction of their ALOHA Packet Radio Network.

A simple ALOHA protocol allows any station on the network to transmit whenever it's ready. If the transmitted packet is not received correctly, the transmitter waits some random amount of time and tries again.

A slotted ALOHA protocol (S-ALOHA) requires that all transmissions on the multiple-access channel be synchronized to start and end within specified time periods or slots. All slots are of the same duration and can contain the maximum length packet. Each transmitter decides on which time slot to use on a random basis.

A slotted ALOHA closed loop control protocol (S-ALOHA-CLC) allows transmitting stations to adjust their transmission control parameters to accomodate varying load conditions on the channel. Each transmitted packet contains a computed variable which reflects, in part, the success that the transmitting station is having in sending packets. All receiving stations monitor this variable and adjust, through use of the algorithms and formulas specified below, their transmit and retransmit controls. Closed loop control of an ALOHA channel allows throughput to approach theoretically maximum limits, provides a mechanism for dynamic changes in the control parameters needed to cope with varying loads, minimizes overall packet delay, and contributes to the efficient use of the channel under heavy load conditions.

2.3.2 Control Parameter Notation

The notation and control algorithms given below were adapted from a paper written by Gerla and Kleinrock (see the bibliography, Appendix A). Their careful study and contribution to the solution of this control problem is acknowledged.

Specification of the ALOHA control procedures uses the following variables:

n - The number of stations currently actively using the L2 channel.

i - Stations are indexed by the variable 'i' where i ranges from 1 to n.

tau - The time in seconds required to transmit a maximum length packet.

ts - The period of a slot in a slotted channel.

W - The history window (measured in slots) maintained by each station.

E - The number of empty slots in W.

S(i) - Successful packets from station i in W.

S - Total successes in W. Computed by summing all S(i) for i = 1 to n.

C(i) - Collisions suffered by station i in W.

C - The total number of collision slots in W.

$$C = W - (S + E)$$

C′ - An estimate of the total number of collisions in W.

$$C' = (C(i)/S(i))*S$$

m - Average number of collided packets per collision. Note that this parameter cannot be measured directly through monitoring the channel.

UC - Interval (in slots) between successive updates of control parameters. Note that UC will be less than or equal to W.

G - Average channel load in window. Computed through the formula:

$$G = (S+C*m)/W$$

In the closed loop control algorithm presented below G will only be estimated because the true value of m is not available.

Gmax - A ceiling value for the G estimate.

Pn(i) - New transmission probability gate value for station i. At each transmission decision point (the time when a new packet is ready for transmission in the simple-ALOHA protocol or the time when a new packet is ready and we have the start of a slot for the slotted-ALOHA protocol) the transmitter draws a random number ranging from zero to one. If the number picked is less than or equal to Pn(i), then transmission commences. For the simple protocol Pn(i) = 1 and transmission always occurs immediately, providing the channel is inactive (there is no carrier at the transmit site). The initial value of Pn(i) is Pn.

Pr(i) - Retransmit probability gate value for station i. At each transmission decision point Pr(i) is used to determine if a previously transmitted packet should be retransmitted. Packets will need retransmission if they are not positively acknowledged by the receiver or if the transmitter detects an error or collision through its own monitoring of its transponded output. All packets that need retransmission must be sent first before any new packets are attempted (the retransmit packet queue has a strictly higher priority than the new packet queue). In the simple ALOHA protocol the transmission decision points occur every tau seconds after an error is detected. In the S-ALOHA protocol there is a decision point at the beginning of each slot. The initial value of Pr(i) is Pr.

Prmax - Ceiling value for Pr(i).

P - The weighted average of all current gate values. The value P is computed by summing Pn(i)*S(i) for all i and dividing by S. The value of Pn(i) is contained in a control byte in each transmitted packet. S(i) is obtained by monitoring the channel and is based on successfully received packets.

DP - The gate value increment. This parameter is used to compute the new values of Pn(i) and Pr(i) and controls their rate of change.

2.3.3 Control Using the Simple ALOHA Algorithm

If the channel duty cycle is less than 20% there is no justification for requiring closed loop control and simple control procedures will suffice. The protocol, in its most basic form, follows these two steps:

1. When a station has a new packet ready to transmit, it transmits it.

2. If the packet was not received correctly, the station waits some random amount of time and then retransmits the packet.

The following paragraphs will clarify some of the details concerning the above two steps.

2.3.3.1 Simple ALOHA Transmission Control

First, in this section and the next we differentiate between new packets and ones that have been previously transmitted. The probability of transmission control gates Pn(i) for new packets and Pr(i) for retransmitted packets have different values. Pn(i) for this protocol is always 1, implying that transmission will be immediate. Pr(i) will be assigned a value when the network starts up, and may be subject to change as the load grows. The priority of packets due for retransmission is strictly higher than that of new packets. We will also restrict each station to have only one unconfirmed packet in the air at any given time. Due to the round-trip signal delays involved, in theory it is not absolutely essential that stations hold back transmissions if there is already carrier present on the output channel. The carrier may already be off at the transmitter site using the channel. Carrier sensing will, however, improve throughput, so it is recommended that new transmissions not start if the channel is already active.

2.3.3.2 Simple ALOHA Retransmission Control

Packet reception may be confirmed in two different ways. The term 'end-to-end' confirmation is used when the higher level processes or programs doing the packet transmitting and receiving positively acknowledge the reception of a new packet. The other confirmation of successful transmission comes from the transmitter's own receiver and its collision detection circuits. Collision detection circuitry does not guarantee safe reception at the final or ultimate receiver, but it does permit the transmitter to immediately reschedule a packet if it is known to be in error, thus avoiding positive acknowledgement timing delays.

The exact procedure for 'waiting a random amount of time' will now be described. This procedure is used for the simple ALOHA protocol because it is consistent with the closed-loop method which follows below.

A station which has determined that it needs to retransmit first waits for the channel to go inactive. It then picks a random number in the range 0 to 1, and if this number is less than or equal to Pr(i) it retransmits immediately. If the number is greater than Pr(i), it delays tau seconds, picks a new random number and repeats the test. This cycle is continued until the retransmission occurs.

By using some mathematical tricks we can simplify the above series of tests and still achieve the same result. Again, we wait for the channel to go inactive and then pick a number in the range 0 to 1. The time we should wait, twait, is then given by the following formula:

twait = random.number * tau * (1-Pr(i))/Pr(i)

The value of twait may be rounded to the nearest tau seconds. If the channel is busy when the time delay expires, the station should wait for the channel to go inactive and then transmit immediately.

2.3.3.3 Simple ALOHA Control Parameter Values

There are only two parameters subject to adjustment in the Simple-ALOHA control algorithm. Consult AMSAT for currently recommended values of control parameters. Typical values for these parameters are listed below:

tau = 1 second
Pr(i) = Pr = .4

2.3.4 Control Using the S-ALOHA-CLC Algorithm

If the channel duty cycle becomes greater than 20%, then there is enough activity on the channel to justify control procedures which will guarantee better throughput under heavy loading and under varying load conditions. The Slotted ALOHA Closed Loop Control algorithm is a method whereby the transmit and retransmit probabilities Pn(i) and Pr(i) are adjusted to accomodate the current channel load, the adjustment causing stations to wait longer when many transmitters are competing for the channel, and then shortening the delay times as traffic is cleared and channel conditions improve.

The key elements of the CLC method are these:

All transmitters are synchronized and start and end their transmissions within fixed time slots. Each transmitter monitors the total number of successfully received packets within a recent time period (the 'history window', measured in time slots), and also keeps a count of its own successes and failures within the window. Each packet transmitted by station i contains a control byte which reflects the current value of Pn(i) for that packet. The Pn(i) values in each packet are recorded by all active stations and their values are used in load calculations specified below. With the data thus recorded, a formula is used to update, at predetermined intervals, the Pn(i) and Pr(i) for the station. Increasing values of Pn(i) or Pr(i) imply that every station in the net is having more success and that less delay is required before transmit and retransmit attempts. As the values of Pn(i) and Pr(i) decrease more delay is introduced causing all stations to slow down, thus reducing channel congestion. The following sections give the exact details of the method.

2.3.4.1 Closed Loop Control Assumptions

This method assumes that channel time is divided into fixed periods or slots, where each slot is ts seconds long and can contain the maximum length packet plus transmitter startup and shutdown time. All slots will start and end on the second's tick from WWV.

Each active station keeps certain statistics over the last W slots and updates its control parameters every UC slots. The update period, UC, will be less than or equal to W.

The station must monitor the channel and count all successfully received packets S. It must also count its own successes S(i).

Finally, at each update interval the station must compute the weighted average of current gate values. The current Pn(i) value for each station is transmitted in the packet in the protocol load control byte which is the byte immediately following the HDLC control field. The right-hand 7 bits of this byte divided by 128 represent Pn(i) for that packet. Use of the high order bit is reserved and it should be set to zero. Stations which are not using closed loop control will set this byte to hex '00'. The weighted average gate value, P, is the sum of all received Pn(i) divided by S.

2.3.4.2 Closed Loop Control Algorithm

The following formulas must be used by each station to update Pn(i) and Pr(i) every UC slots.

(a) Estimate Collisions:

If C(i) = S(i) = 0 then:

If S = 0, let G = 0 and go to (c)
Otherwise, let G = 1 and go to (c)

If C(i) > 0 and S(i) = 0 then:

Let G = Gmax, P = min(P,Pn(i)) and go to (c)

If S(i) > 0 then:

Let C' = C(i) * S / S(i) and go to (b)

(b) Estimate total channel load G:

$$G = (S + C')/W \quad \text{with} \quad 0 \leq G \leq Gmax$$

(c) Derive new probability gates:

$$Pn(i) = P - (G - 1) * DP \qquad 0 \leq Pn(i) \leq 1$$

$$Pr(i) = \min(Pn(i), Prmax) \qquad 0 \leq Pr(i) \leq 1$$

2.3.4.3 Slotted ALOHA CLC Parameter Values

Consult AMSAT for currently recommended values of control parameters. The following are typical values:

ts = 1	Slot size in seconds
W = 64	History window (slots)
UC = 16	Update period (slots)
Pn = .5	Initial new packet transmit gate

Pr = .5	Initial retransmit packet gate
Prmax = .5	Ceiling value for Pr(i)
DP = .25	Probability increment
Cmax = 2	Ceiling value for G estimate

[Some simulation studies are required to properly analyze the effect of changes in the control parameters and to determine which features of the protocol are really useful and which can be discarded. Here is a list of some questions which need investigation:

1. Performance curves for Simple ALOHA
   a. Effect of changing packet length.
   b. Effect of carrier sensing.
   c. Variations caused by changing Pr(i).

2. Performance curves for S-ALOHA-CLC
   a. Effect of changing packet length.
   b. Effect of carrier sensing.
   c. Benefits of slotting.
   d. Parameter settings and optimal values.

3. Determining the optimal load level to switch from the Simple-ALOHA to S-ALOHA-CLC.

The simulation could be written in PASCAL using discrete time steps.]

Chapter 3

LEVEL 3 INTERFACE: NETWORK SPECIFICATIONS

3.1 Datagram Network Characteristics

The architecture of data communications networks in use today is diverse and many different types of connecting arrangements are possible. There are point-to-point connections, multi-point networks, switched circuits, virtual circuits, switched virtual circuits, etc. The AMICON network is one example of a fully-connected packet switching network. The term fully-connected is used because there is the possibilty of a connection from every station in the net to every other station (through use of the multiple-access broadcast channel). The network is a packet switching network because all user information is broken into small packets of data, allowing many different users to have multiplexed access the channel.

The technology of building packet switching networks is under active development currently, and there are many different types of packet switching services available today. The type of service that best characterizes the AMICON network is referred to as a datagram service:

A datagram is a self-contained packet which carries sufficient information such that it can be routed from source station to destination station without reliance on any previous exchanges between source and destination and the communications network. The data field within a datagram will be kept intact and not split-up or altered in any way by the network.

The delivery of a datagram is not guaranteed. There is a high probability of delivery, but it may occasionaly be lost. The data within a properly received datagram, however, will have an extremely low probability of error.

The sequence in which datagrams are supplied by sender is not necessarily the sequence in which they will be received by the receiver. All datagrams in transit in the network are treated as independent entities.

Under some circumstances it is possible for a duplicate transmission to occur, causing the same datagram to appear more than once at the receiver.

In summary, a datagram service is an extremely simple but fairly fast transport service which serves as the foundation on which higher level communications protocols are built. These higher level protocols (Level 4 and above) are responsible for end-to-end acknowledgments, sequence checking, retransmissions of lost packets, flow control and other controls which will guarantee a complete and orderly passage of data from sender to receiver.

3.2 Packet Format

The packets or datagrams flowing through the AMICON network will have the format described below:

Bytes	Field	Description
1 to n	Framing	Initial framing or synchronization bytes
1	Address	HDLC address byte
1	Control	HDLC control byte
1	Protocol	Protocol load-control byte
1 to n	Receiver	Receiver Call Group Field
1	'='	Separates Receiver Call Group from Sender Call
1 to n	Sender	Sender Call Field
1	';'	Terminator for datagram address fields
0 to n	Data	Datagram data field (unrestricted in content)
2	CRC	Packet checksum bytes
1 to n	Framing	Terminating framing or pad characters

The initial framing or synchronization bytes are not detailed here. The beginning-of-packet control sequence is described in the Level 2 description of a packet.

The HDLC address field consists of a single byte. Use of extended address fields, as provided for in the standard, is not recommended. The contents of this address field are not used by the Level 3 protocol. Packets which are used for testing should set the address byte to hex '00'. Packets which are not using the address byte for higher level protocol functions should set this byte to the all-parties-addressed code, hex 'FF'.

The HDLC control field consists of one byte. Use of an extended control field, as provided for in the standard, is not recommended. The contents of the control field are not used by the Level 3 protocol. Stations not using this byte for control purposes should set it to hex '03', which is an HDLC Unnumbered Information frame.

The protocol load-control byte is used by the S-ALOHA-CLC protocol control software. The contents of this byte are detailed in the Level 2 description of the closed-loop-control algorithm. Stations not using closed loop control should set this byte to hex '00'.

The receiver call group field is a field which contains the call or calls of the receiver of the datagram. See Section 3.3 below.

The single ASCII character '=' separates the receiver call or calls from the sender's call. See Section 3.3 below.

The sender's call field is a field which contains the call of the datagram's sender. See Section 3.3 below.

The single ASCII character ';' terminates the datagram addressing fields. See Section 3.3 below.

The packet data field is described in Section 3.4 below.

The two cyclic-redundancy-check (CRC) bytes provide error checking for the contents of the packet. The contents of these bytes are detailed in the Level 2 description of the packet.

The terminating framing or pad bytes are described in the Level 2 description of the packet.

3.3 Packet Node Addressing

The datagram addressing field starts with the byte immediately following the protocol load-control byte, and ends with a semicolon (;). The function of this field is to specify the call of the sender of the datagram and to specify the call or calls of all intended receiving stations.

A point-to-point datagram is a datagram which is intended to be received by one station only and which should be discarded by all other stations.

A broadcast datagram is a datagram which is to be received by all stations currently listening to the channel. A datagram containing a CQ or a bulletin of general interest would be typical examples of broadcast datagrams.

A multi-cast datagram is a datagram which contains information intended for a selected group of stations having a special interest in a particular topic or participating in a net. The multi-cast group is specified by one or more 'general call' group addresses and optional qualifiers as outlined in Sections 3.3.3 and 3.3.4 below.

3.3.1 Packet Node Addressing Syntax

The datagram address field has the following general form:

Receiver=Sender;

The Sender is the call of the originator of the datagram. It is a specific call having the syntax outlined in Section 3.3.2.

The Receiver field specifies the station or stations to which the datagram is being transmitted. The Receiver address field contains either a single Call Group or several Call Groups separated by commas. Each Call Group may have an optional qualifier. A Call Group is either a Specific Call Group (Section 3.3.2) or a General Call Group (Section 3.3.3). Examples:

Receiver1=Sender;
Peceiver1,Receiver2=Sender;
Receiver1.Qualifier,Receiver2=Sender;
Receiver1.Qualifer,Receiver2,Receiver3.Qualifier=Sender;

The ASCII '=' character separates the Receiver and Sender fields. The ASCII semicolon terminates the datagram addressing field.

3.3.2 Specific Call Group Syntax

A Specific Call Group is the call of a specific, individual station. An optional qualifier may be suffixed to the call (See Section 3.3.4). Lowercase ASCII characters will be converted to uppercase by the program scanning the Call Group. Any ASCII space characters found in the Specific Call field will be discarded. An ASCII slash character, '/' , may be appended to the call to show portable operation. If the specific call is used in the Receiver field, it may be preceded by a negation operator (See Section 3.3.3).

3.3.3 General Call Group Syntax

A General Call Group is a specifier which allows a sender to transmit a datagram to a group of stations. It is the mechanism which implements the broadcast and multi-cast modes of packet addressing. Whereas the Specific Call addresses a specific, individual station, the General Call allows construction of address templates which are not specific, and which may be used to match any number of individual calls.

The key to constructing a General Call address template is the use of certain characters which are 'wild-card' characters, that is, characters which will match one or more letters or numbers in a text string. Two wild-card characters are now defined:

The character '?' may be used to match any other single letter or number. For example,

KL7???	matches all Alaskan 2 x 3 calls
W1?BC	matches W1ABC, W1BBC, W1CBC, etc.
VE????	matches all six character VE calls

The character '*' matches any string of numbers or letters including the null string. For example,

*	matches every call in the world
W*1*	matches all W calls in the first call district

The characters '?' and '*' may be intermixed in any manner in creating a template. All lowercase letters will be converted to uppercase. Any ASCII blanks embedded in the text strings will be discarded. A receiver scanning an incoming General Call Group should accept the datagram if the receiver's call matches any template given in any of the address fields in the Receiver field.

If the General Call Group is preceded by a minus sign, then the datagram should be discarded if the receiver's call matches the negated address template. For example,

,-KH6=KH6XYZ;

is a datagram addressed to every station listening to the channel except any other KH6 stations

3.3.4 Call Group Qualifiers

Each Specific Call Group or General Call Group may optionally be followed by a qualifier text string. The function of the qualifier text string is to restrict very general call addressing to specific stations by functional interest, mode of operation, or any other criteria which may be agreed on by two or more stations.

A qualifier text string begins with an ASCII period and immediately follows the Call Group. The text string is terminated by a comma or the equal sign separator. The following are some examples of qualifiers:

.CQ	The datagram is addressed to any station matching the Call Group which wishes to establish a connection with a new station.
.SSTV	The datagram is addressed to the specified Call Group and particularly those stations interested in slow scan TV.
.AMSAT	To stations interested in receiving AMSAT related bulletins.
.NTS	To stations handling formal message traffic.
.xNET	To stations belonging to net x.

A list of commonly used qualifiers will be published by AMSAT once their use has been established.

3.3.5 Call Group Addressing Examples

The following set of examples demonstrates some of the possible legal combinations of the above Call Groups and Qualifiers:

K1HTV=KA6M;

A point to point datagram from KA6M to K1HTV.

*.QST=W1AW;

The datagram is a bulletin from the ARRL addressed to any station interested in the latest ARRL news.

*.CQ=WA2LQQ;

Station WA2LQQ is calling CQ and looking for a new contact.

A*,K*,N*,W*=KA6M;

A datagram intended for U.S. stations only. Will also end up in some rare DX locations.

*.DDX=W3IWI;

To any station participating in the digital DX data contest.

K1HTV,W6SP,W6XO,WA2LQQ,*.AMSAT=KA6M;

A datagram to the specific stations listed and any others interested in AMSAT related bulletins.

3.4 Packet Data Field

The datagram packet data field contains data or control information which the sender desires to transmit to the receiver. The contents of this field are not interpreted by Level 3 software. The only constraint is that the length of the data field plus the control and addressing fields must not exceed the maximum packet length.

[The addressing mechanisms described here are general enough to construct practically any desired subgroup. Addressing specific countries or geographical areas, though, leads to some awkward constructions and it would be worthwhile to invent some mechanism to make a geographical target area easier to do.]

Chapter 4

LEVEL 4 INTERFACE: APPLICATIONS

[There is some question whether applications standards should even be proposed at this time. It may be much too premature and perhaps it would be better for users to have some time to experiment first.]

4.1 File Transfer Protocol

The transmission of complete files through the network will not be covered by this revision of the specification and is a subject for further study.

[ARPANET uses a file transfer protocol known as TCP. It would be a good starting point and perhaps we can adopt a compatible subset for our use. The original reference material for TCP may be found in 'A Protocol for Packet Network Intercommunication' by Vinton G. Cerf and Robert E. Kahn, IEEE Transactions on Communications, Vol. COM-22, pp. 637-648, May, 1974.]

4.2 Graphic Standards

The transmission of graphics over the network will not be covered by this revision of the specification and is a subject for further study.

[Should AMSAT even attempt to define a standard?]

4.3 Image and Video Transmission

The transmission of video images over the network will not be covered by this revision of the specification and is a subject for further study.

[Should AMSAT even attempt to define a standard?]

4.4 Digitized Voice Transmission

The transmission of digitized voice packets over the network will not be covered by this revision of the specification and is a subject for further study.

[Should AMSAT even attempt to define a standard?]

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Appendix B - ISO Specification 3309

Appendix C - Datagram Addressing Syntax Diagram

Appendix D - Distribution List

David W. Borden, K8MMO
Route 2, Box 233B, Sterling, VA 22170
Home: 703-430-7642 Office:

Col. John Browning, W6SP, AMSAT Board Chairman
6202 Lochvale Dr., Rancho Palos Verdes, CA 90274
Home: 213-541-4997 Office:

Bob Bruninga, WB4APR, Director and Computer Trustee of AMRAD
907 Ninovan Road, Vienna, VA 22180
Home: Office:

Bob Carpenter, W3OTC
12708 Circle Drive, Rockville, MD 20850
Home: Office:

Dr. Tom Clark, W3IWI, AMSAT Director & Executive Vice President
6388 Guilford Rd., Clarksville, MD 21029
Home: 301-286-3113 Office: 301-344-5957

Mark Corbitt, WB4FNE/6, Data Communications Advisor to the ARRL
6568 Beachview Drive, No. 311, Rancho Palos Verdes, CA 90274
Home: 213-377-1385 Office: 213-535-4321

Dr. John DuBois, W1HDX, AMSAT Special Systems Consultant
241 Crescent Ave., Waltham, MA 02154
Home: 617-263-7004 Office: 617-891-9029

Gary Fariss, W6KYF
18983 Saratoga Glen Place, Saratoga, CA 95070
Home: 408-257-0948 Office: 408-734-6857

Gary Hendra, WA6SUW
3249 Lantern Court, San Jose, CA 95111
Home: 408-629-5863 Office: 415-494-7400 x6280

Joe Kassar, G3ZCZ, Editor of ORBIT Magazine
11532 Stewart Lane, Silver Sprint, MD 20904
Home: Office:

Mark Kaufmann, WB6ECE
14100 Donelson Place, Los Altos Hills, CA 94022
Home: Office: 415-948-3777

Larry Kayser, VE2QB
Ottawa, Canada
Home: Office:

Doug Lee, K6TDR
225 N. Clark, Ave., Los Altos, CA 94022
Home: 415-948-3601 Office: 415-326-6200 x2418

Wally Linstruth, WA6PJR
2413 Burritt Ave., Redondo Beach CA 90378
Home: 213-542-3290 Office:

Dr. H. S. Magnuski, KA6M, AMICON Network Consultant
311 Stanford Ave., Menlo Park, CA 94025
Home: 415-854-1927 Office: 415-856-7421

Howard L. Nurse, W6LLO
665 Maybell Ave., Palo Alto, CA 94306
Home: 415-493-0371 Office: 415-732-2710 x2559

Gary H. Price, W6IRA

Home: 415-732-1008 Office: 415-326-6200 x4820

Dr. John Pronko, W6XO, President, Project OSCAR
230 Hawthorne Ave., Los Altos, CA 94022
Home: 415-941-6988 Office: 415-493-4411 x45179

Vern Riportella, WA2LQQ, AMICON Coordinator
Box 56, Warwick, NY 10990
Home: 914-986-6904 Office: 201-768-2500

Bob Rouleau, VE2PY
1050 Churchill, Mt. Royal, Quebec H3R 3B6
Home: 514-341-7806 Office:

R. Satterlee, WB6VAL
1212 W. McKinley, Apt. 5, Sunnyvale, CA 94086
Home: 415-969-4451 Office: 415-964-5700 x227

Paul Zander, AA6PZ
86 Pine Lane, Los Altos, CA 94022
Home: 415-941-7821 Office: 415-857-3776

Rich Zwirko, K1HTV, AMSAT Director and Vice President
34 Montclair Dr., Manchester, CT 06040
Home: 203-646-5726 Office: 203-522-1080

---- NOTES ----